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# GIS in Education: Across Campuses, Inside Facilities



# Table of Contents

## 3 Introduction

### Planning and Portfolio Management

6 Building Smart from the Ground Up

10 A 3D GIS Solution for Campus Master Planning

13 Building a University of the Future

### Operations and Maintenance

20 Taking Efficiency to the Next Level at City College of San Francisco

23 A Garden's-Eye View

26 University Enhances Its Logistical Tracking System with GIS

30 Smartphone App Aids District's Facilities Maintenance

33 Campus iPhone App Helps University of Oregon Students Negotiate Their Way around Campus

## 38 A New Dimension

### Security, Compliance, and Sustainment

43 High Tech Leads to Higher School Safety

47 No Debate about GIS on Campus

52 Going Green at Pomona College

56 Learn More

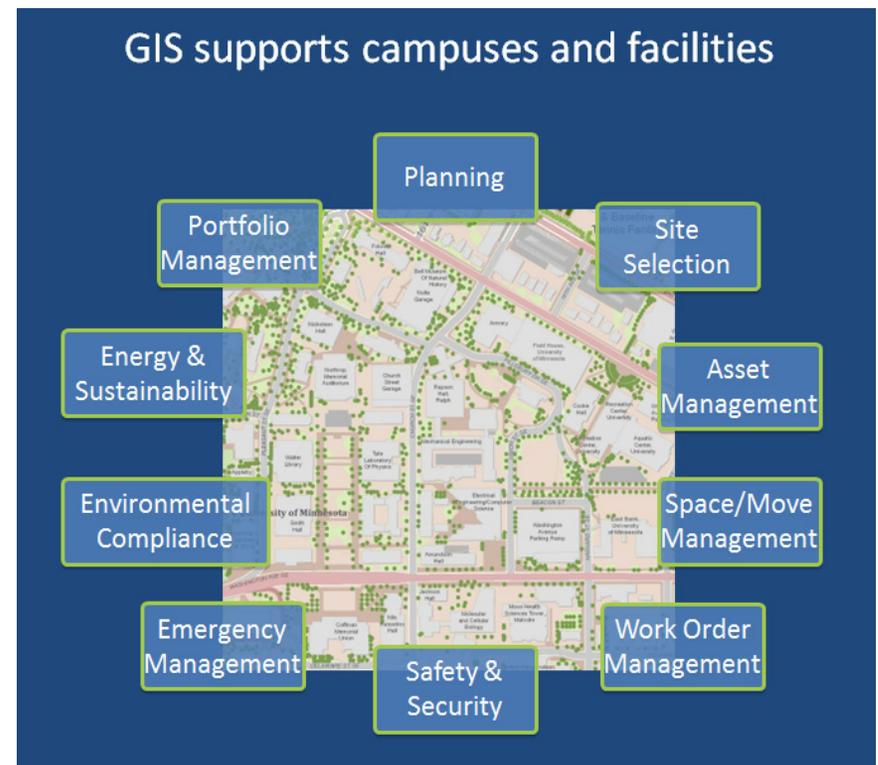
# Introduction

George Dailey and Shelli Stockton, Esri

Educational institutions—universities, colleges, schools, libraries, and other centers of learning—are physical entities. Typically when we picture these places, we see people—the learners themselves and the persons who support that learning. Possibly a bit more invisible to our eyes is the actual geography these people inhabit, experience, and navigate—the physical environment of buildings, campuses, and districts. These places are a mix of real property, associated physical assets, and supporting infrastructure. These entities and their component parts have spatial footprints, exterior and interior facets, multiple dimensions, and life cycles. As figuratively "living" entities, campuses and educational districts grow and change and require stewardship—planning, management, maintenance, and sustainment. Within and across all of these, geographic information system (GIS) technology and approaches play vital roles.

GIS is a technological tool for comprehending geography and making intelligent decisions through spatial visualization and analysis. GIS can, for instance, help manage infrastructure both outside and inside buildings, providing a comprehensive way to optimize space, move staff and classrooms efficiently, map the condition of assets, and ensure adherence to specific standards

and policies. As a spatial technology, GIS can be used to explore educational institutions across all scales of geography—a system, a campus, a building, and even a particular asset. As an integrative technology, GIS works collaboratively with other toolsets (like CAD, EAM, CAFM, CMMS, and related software),



helping leverage geographic and common facilities databases in ways that enhance their effectiveness. In the world of educational buildings, campuses, and districts, GIS—alone and in tandem with other facilities-focused technologies—is making a difference in stewardship across a range of tasks and functions.

This e-book provides a rich assortment of best practice examples on the application of GIS in a number of educational settings. The articles are organized into three groups—planning and portfolio management; operations and maintenance; and security, compliance, and sustainment—based on each article's dominant theme. After the articles, there is a short list of additional resources on GIS for facilities and geodesign, as well as pathways to the Esri Community Maps, Facilities GIS, and Education programs.

# Planning and Portfolio Management

# Building Smart from the Ground Up

Kuwait University, Sabah Al-Salem Campus, Uses GIS to Design and Build Multibillion-Dollar Development Initiative

Stu Rich, PenBay Solutions LLC

Kuwait University is embarking on one of the most ambitious campus development projects in the world. The massive University City is being designed and built from the ground up and will emerge over the next four years of construction as part of a multibillion-dollar development initiative.



All the university's information is stored in a geodatabase and is easily accessed using a Flex viewer.

In addition to teaching GIS, Kuwait University chose to apply the geospatial concepts discussed in the classroom to support the entire process of designing, building, and operating the

huge new University City at Shadadiyah Campus. In early 2010, Kuwait University recognized a need for specialized consulting and documentation of requirements for geodatabase design of the Sabah Al-Salem University City project. For the plan to be successful, the needs of both planning company Turner Projacs and Kuwait University were to be incorporated in the details of design and construction of the project.

Those needs included using GeoDesign processes and techniques to bring value to each stage of the facility life cycle, from site analytics and design to planning and construction, as well as operations, security, and sustainability. This ambitious vision posed many challenges and represented a level of enterprise data development unmatched in the world today.

## Modeling and Storing Data for an Entire Campus

To address these complex challenges and establish a common information foundation throughout the entire life cycle, Kuwait University turned to OpenWare Information Systems Consulting Company, Esri's distributor in Kuwait. Esri's reputation and proven performance in the enterprise GIS arena made it a natural place to start framing a system architecture to support the

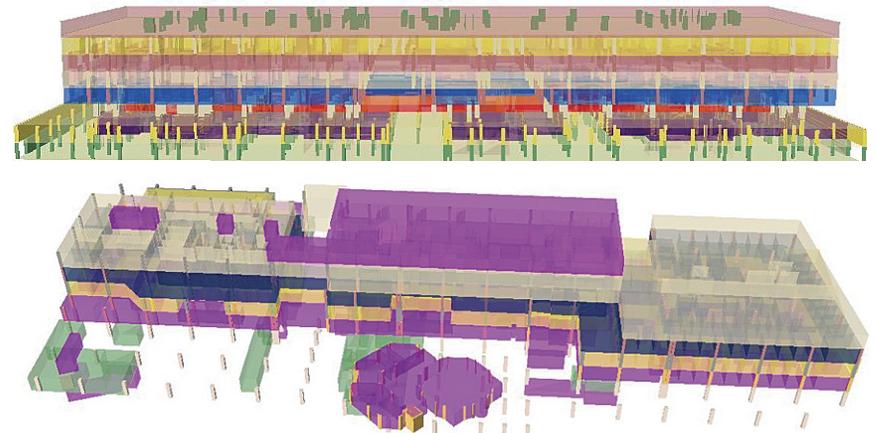
vision. OpenWare, along with Esri Partner PenBay Solutions LLC, headquartered in Brunswick, Maine, and Turner Projacs, based in Doha, Qatar, used GIS expertise to create a strategic road map for understanding the milestones and level of effort of this facilities information infrastructure project.

One of the major challenges in addressing the scope of these ideas was how to model and store data for an entire campus—data spanning indoors, outdoors, and underground, connected and temporal. The process that ensued was a major effort to bring international experts to the table to design a unique, world-class data model for implementing this vision in GIS. The result of this effort is one of the more remarkable all-encompassing data models ever implemented—one which will support the full life cycle of Kuwait University's vision and beyond.

The goals of the project included establishing a powerful GIS system for the new university based on a comprehensive geodatabase that integrates as-built design data. ArcGIS for Server, along with ArcGIS for Windows Mobile and many web applications created with ArcGIS Viewer for Silverlight, is used to manage the campus assets and provide a platform for future geospatial needs. Using ArcGIS as the foundation technology, the project team has created a number of advanced applications.

## Master Plan Support

Coordinating a design and construction job of this size and duration requires a small army of dedicated experts and many years of planning and revisions. The project is engaging firms from around the world to design specialized structures for the 100-plus proposed buildings on campus. The master planning process is one of the first places where GeoDesign plays an integral role, optimizing program elements and unifying the designs from individual bid packages into a single seamless view. By doing so, planners and decision makers can recognize design impacts and understand considerations that would be missed without a holistic understanding of the sum of the design parts. Esri technology allows the team to do this in 2D and 3D, both important at different points in the master planning process.



Project progress performance indicators can be observed in a 3D view of the campus.

## Construction Management and Planning Support

At the peak of construction, there will be more than 10,000 construction personnel on-site daily and untold vehicle trips requiring access to building sites for deliveries. The construction management team is a seasoned group of professionals that has traditionally worked through planning and daily operations using paper drawings and markup pens. Through the use of GIS, team members can now retrieve, update, and analyze construction logistics and scheduling data, temporary staging locations and assignments, and daily operations across the entire campus through a simple web viewer. Daily standup meetings utilize this information through the Construction Management viewer and allow quick sketching and markup, which is printed and taken to the field. This quick temporal snapshot helps meet the demands of the day, as well as the longer-term planning activities, to make construction logistics run smoothly.

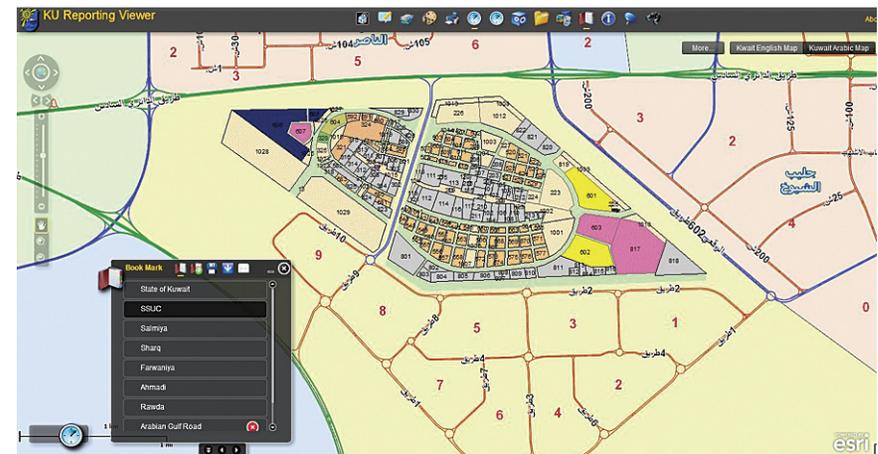
Because construction implementation rarely occurs without the need for a design change, the GeoDesign process includes an adaptive management piece that allows design changes and impact assessment mid-implementation to ensure that program goals are met and the design change has no unforeseen impact on other design elements.

Equally important is the visualization of construction over time (4D). Construction managers and decision makers can view and

identify spatiotemporal clashes, accessibility problems, and other logistical issues before they happen.

## Status Monitoring and Reporting

As the project progresses, reporting and schedule monitoring are critical aspects of project controls. Because so many tasks are dependent on other critical milestones, there needs to be a razor-sharp view of progress for all the ongoing activities. The GIS Reporting web application takes data from the tabular project report and displays it on the map, showing where activities are falling behind and which adjacent efforts might be impacted. This quick visual reporting accompanies all progress reports for a full project snapshot that can be easily understood by anyone on the project team.



Status reporting is easy with the master plan map.

Another way of visualizing progress and key performance indicators is in a 3D GIS view of the campus. Using ArcGIS and ArcGIS Explorer, project leaders and executives can view an up-to-date snapshot of building construction progress in 3D or request high-level reports.

## Space Programming

While the campus buildings are not going to be completely finished and occupied for years, there is a requirement to begin the massive process of space programming for the academic occupancy. Because of Kuwait University's GIS vision, it is receiving the floor plan designs in geodatabase format. This means that even prior to completion of construction, university staff will be able to do scenario planning with that data, assigning personnel and assets to define an optimal space program. It also supports validation of space requirements by size and type, as well as proximity to building services or required facilities. This is done for each floor, throughout the entire building and out to other buildings.

The benefits of using GeoDesign processes to support facility life cycle management are numerous. The use of GIS strengthens and streamlines the design and construction phases of the campus development process and implements key applications to support operations management while establishing a GIS infrastructure that can be expanded to other advanced application areas. This project encourages the development of a

campus GIS unit that works in conjunction with the current team to start building a core technical capability to eventually take over the operational system and expand to future applications. Additionally, the same technology and much of the data may be useful for helping support academic programs, including a living laboratory that students can use to develop new application ideas.

For additional information on this project, see chapter 6 in *Geodesign: Case Studies in Regional and Urban Planning*, published by Esri Press.

For more information on how GIS assists organizations around the world in their facilities management needs, visit [esri.com/fm](http://esri.com/fm). Also visit [esri.com/geodesign](http://esri.com/geodesign).

(This article originally appeared in the Fall 2011 issue of *ArcNews*.)

# A 3D GIS Solution for Campus Master Planning

Karen Richardson, Esri

The University of Rochester (U of R) is a major research university located in Rochester, New York, with approximately 4,600 undergraduate and 3,900 graduate full-time equivalents. The university, along with its affiliated medical center, Strong Memorial Hospital, is the largest employer in the Greater Rochester area and the sixth largest employer in New York State.

Founded in 1850, the university and its medical center have grown dramatically in size. Today, the university continues to expand at a rapid pace, with officials planning to expand at approximately 1,000,000 square feet every decade.

Rapid expansion has led to a complex and often difficult-to-manage matrix of utilities located throughout the university campus. The university has responsibility for domestic water, chilled water, hot water, steam, condensate return, fiber-optic, telephone, natural gas, storm sewer, sanitary sewer, electric distribution, street lighting systems, and medical gases inside the hospital and research complex. None of these utilities follow a traditional right-of-way layout—systems often crisscross each other to form what looks like a complicated underground spider's web. This web of utilities complicates new installations and repairs. Utility excavations are a constant concern.

Since the university includes a medical campus, it is imperative that utility systems function at all times.

To better understand and organize its utility infrastructure, the University of Rochester hired Bergmann Associates, an Esri Partner in Rochester, New York, to develop a solution using ArcGIS Desktop and ArcGIS 3D Analyst. Initial work for the university included georeferencing hundreds of existing utility plans and as-built drawings and converting them into file geodatabase feature classes.

The utilities are in the process of being represented as seamless layers for each system instead of isolated drawings containing multiple systems. This will greatly simplify the internal "call-before-you-dig" process. Instead of sorting through thousands of drawings and trying to mentally edgematch them, employees at Central Utilities will have access to a 3D model of the university with utility systems completely mapped. This solution should enable the university to significantly recoup the previous investment from its library of utility drawings and surveys.



Using the ArcGIS 3D Analyst ArcGlobe software, hundreds of existing utility plans and as-built drawings were georeferenced and converted into file geodatabase feature classes in a seamless layer for each system, greatly simplifying the internal "call-before-you-dig" process. (Aerial imagery from Pictometry International)

## Campus Master Planning

Following the launch of its successful new solution for infrastructure development management and the successful development of the utility GIS layers, the university realized that these new solutions could potentially enable comprehensive campus master planning and enhance decision making, promotions, and fund-raising; furthermore, it recognized that these new solutions could be used in conjunction with the 20-year master plan prepared by Ayers Saint Gross, a Baltimore, Maryland-based architectural firm specializing in academic

campus planning and design and adopted by the University Trustees in October 2009. The plan envisions major expansion of the health care, research, and academic enterprise to include realigning roads and improving expressway access.

To address these needs, Bergmann Associates provided Integrated Design and Management (IDM), a business solution that could accomplish all goals by providing a single, managed 3D GIS virtual campus database.

The U of R IDM Virtual Campus has three main components:

- An enhanced lidar terrain dataset
- High-resolution aerial photography
- High-detail, high-resolution structure models

For terrain management, Bergmann utilized an Esri terrain dataset. The dataset was built as a hybrid model, using smoothed lidar masspoints enhanced with surveyed elevations and breaklines. This allows the capture of abrupt elevation changes (such as retaining walls) in a vector format. It also allowed the university to capitalize on its previous survey experience; Bergmann used publicly available lidar and captured survey elevations from previous as-built drawings. The terrain was built with no additional survey or lidar expenditures.

The use of existing survey data allowed Bergmann to correctly model elevation changes (such as loading docks) around the

foundation of a structure, providing a high level of site-specific detail that remote mass-collection technologies cannot match.

Draped over the terrain is ultra-high-resolution 4-second/pixel orthoimagery from Esri Partner Pictometry International Corporation of Rochester, New York. The resolution of this orthophotography is high enough that manholes, access points, catch basins, striping, and other assets are clearly visible—giving Bergmann and the university a high degree of confidence in mapping and digitizing. Additionally, the photography serves as an ideal base for the IDM Virtual Campus, visually anchoring the university's building models.

As an architecture and engineering firm, Bergmann Associates has a high level of in-house 3D modeling experience. Industry-leading 3D models and photorealistic renderings are commonly part of its deliverables for architectural or land development projects. Bergmann put that expertise to good use, building extremely detailed structure models for the campus.

Features are stored as a textured multipatch feature class. The high-resolution, photorealistic 3D environment allows planners at the university to see how a proposed building will interact with the existing environment before it is built, ensuring that the size, scale, and style of a proposed building are harmonious with the existing built environment.

The goal of the university is to enable the user to easily view all available floor plans for a structure by identifying it in ArcGIS

3D Analyst and choosing a hyperlink to the appropriate plan. Additionally, the source site plans and as-built drawings for the utility system would be available via embedded hyperlinks.

## On the Horizon

The entire campus master plan is being integrated into the 3D model as a time-enabled 3D feature class. The user will have a time slider that will move the model forward through time, showing the plan phasing—building demolition and construction, roadway realignments, growth of landscaping, etc. This is an extremely powerful visualization and planning tool, remarkably effective at presenting complicated three-dimensional and time-phased information.

The University of Rochester has made a major investment into Esri 3D GIS technology and has begun to build a 3D virtual campus that not only models the existing built environment but also looks into the future. It has given the university the capability to centralize campus maps, plans, and planning content. Further, it has the ability to reduce information silos and improved data access for future development planning and review. Using Esri software as the foundation for a 3D campus master-planning tool, Bergmann Associates and the University of Rochester are helping pioneer the usage of 3D GIS-based solutions for campus planning.

(This article originally appeared in the Summer 2011 issue of ArcNews Online.)

# Building a University of the Future

Karen Richardson, Esri

The University of Calgary in Alberta is considered one of the top research universities in Canada. It has more than 29,000 students and more than 4,000 academic and support staff. The university began using GIS for academic research 20 years ago and has now standardized the management of its geographic information with Esri technology. Realizing the value of geographic analysis for informed decision making, it has expanded the use of GIS to manage not only academic data but also institutional and administrative data.

## Running a Smart Campus

The main campus has more than 20 academic buildings occupying more than 200 hectares, which is larger than Calgary's entire downtown core. In 2008, the university embarked on a \$1.5 billion campus expansion, the largest capital expansion project in its history. Knowing that implementing a project of this size and continuing to maintain so many buildings would require a comprehensive understanding of every aspect of the campus—its landscape, people, buildings, and infrastructure—university planners relied heavily on ArcGIS and [GeoDesign](#) principles to help analyze and evaluate the impacts of design alternatives early in the development process.



The University of Calgary uses ArcGIS to manage a \$1.5 billion expansion and maintain the facilities on its 200-hectare campus.

The university maintains institutional data used for facilities management in a central data warehouse. Esri's [ArcGIS for Server](#) serves as the front-end technology that pulls data from ARCHIBUS, Esri Partner (Boston, Massachusetts) and creator of a solution used to manage spatial data and real estate, infrastructure, and facilities information. These recently integrated systems enable users to visualize and analyze both interior and exterior building data that's important to understanding how the campus currently works. Defining how the landscape works and evaluating whether it is working well are key tenets of the GeoDesign framework for landscape change. Evaluation of current processes allows proper "baselining" and the identification of key metrics against which design alternatives can be measured. The result is improved site planning and facilities

design optimized for cost-efficient management and sustainability well after the initial project work is complete.

Understanding the physical constraints of a property is equally important. During site assessments, planners and landscape architects alike need to know how water flows across a property. This question came up early in the design phase, before construction, when the facilities management team approached the university's GIS team to create a campus drainage basin model. While there are no drastic slopes on the campus, there are low spots. Coupled with Calgary's high water tables, understanding these environmental issues was an important design constraint. If a basement is built in a particular location, the probability of flooding may be higher. Knowing where rainwater would drain allowed the team to see where flash floods might occur and then mitigate any potential dangers.

Understanding the terrain—the physical lay of the land—and how it affects drainage across this particular landscape has proved to be invaluable. The drainage basin model has been leveraged in planning new building sites and the expansion of the storm sewer system, including an innovative research project for filtering surface water before it enters the sewer system.

### **3D Data to the Rescue**

The team combined light detection and ranging (lidar) data with high-resolution, orthorectified aerial photographs to create the

drainage model data. ArcScene allowed decision makers to view and process the data in 3D while analyzing the effects of new construction sites on the existing grounds.

Using lidar to map the campus allowed the team members to look not only on the ground but in the trees, as well. They recorded and processed the height of every tree on campus to provide even more information necessary for relandscaping after the expansion project, as well as to understand the position of shadows on potential buildings. Armed with this information, the team was able to optimize the planting of five trees for every tree removed during construction, along with native, low-water vegetation, helping the team achieve greenhouse gas and water use reduction goals.

Once the surface models were completed, the team generated 3D building models to use for shadow simulations during the next construction phase. Traditionally, the models have been leveraged to ensure that new buildings do not obstruct the views of existing buildings. In this case, the shadow models were used to track the sun's effect on a glass exterior compared to a solid wall structure. This method of optimizing the heating mechanics of buildings is an important consideration in an area as far north as Calgary, where sun angles change drastically depending on the season. In the summer, the sun is high, creating narrower shadows; in the winter, the reverse is true. Simulating 3D shadow effects based on sun angle allowed team members to calculate just how long a building would sit in shade at any time of year,

enabling decisions to be made on the heating needs and estimated costs to maintain the comfort level of that specific building.

As with many GIS projects, the development of one application often generates additional benefits. With the surface models in place and the building sites located, there was an urgent need to model the campus irrigation system. An application was developed to help map the changes caused by the construction. The irrigation model also provided the ability to monitor water usage and maintain asset inventories. This innovative application created a model for managing 8,500 sprinkler heads across campus and has helped grounds personnel better understand and manage the system. Knowing the flow rate and tilt angle of each sprinkler, the university is now able to calculate the volume of water it sprays, as well as the area it covers. The application can be used for the life of the campus and allows it to conserve water by reducing overlap and avoiding spraying water on roads and pedestrian walkways.

## Coordinating Solutions

The GeoDesign process opened many new avenues to explore to increase efficiency around campus, even in areas where it wasn't expected. In a synergistic move with the new construction, the information technologies (IT) department also used ArcGIS to consolidate several computer centers where remote computer systems were once maintained. The consolidation freed up new

space for faculty to use and has led to better communication and system coordination across campus. It also allowed a reduction in utilities costs for electrical and cooling systems.

"Using GIS as a decision-making tool is a smart way of gathering all the things you already know and placing them in a single spot so you can see the entire picture," says Tom McCaffrey, GIS coordinator, University of Calgary. "Understanding each layer of data as a separate entity is one thing; combining several layers together to get a coordinated solution to a complex problem is a completely different scenario. It's the difference between thinking in two dimensions versus thinking in three or four."

This understanding of how ArcGIS can be applied to different problems led the IT telecom group to reach out to the GIS team for help creating an application that would track telecom network lines, utility corridors, wiring closets, and utility shafts throughout the campus. While general maintenance for utilities and computer networking systems can be overwhelming if left unchecked, the ArcGIS for Server web-based application, when completed, will serve up 3D diagrams of the networks that administrators can edit and analyze at any time. Service technicians will also be able to trace, track, and repair faulty wires and equipment as these tasks are necessary. The system will enable them to monitor real-time data, plan networks, and prevent costly technical problems.

## Improving Asset Management and Reducing Risk

The university currently needs to renew and maintain the exterior roofs of more than 90 buildings on several different campus sites. To make this process more efficient, the GIS team created a web mapping application that allows editing, updating, measuring, and reporting on government funding spent on reroofing the campus. Using ArcGIS, the team is now able to more effectively track life cycles and warranties of the roofing materials, which can potentially lead to thousands of dollars in savings on roofing jobs. Data on structures reported to the government is now documented using an accurate spatial and temporal method that provides strong accountability for how government money is spent. GIS has virtually eliminated the need for manual roof measurements that cost both time and money, as well as pose a potential safety risk.

From a risk management perspective, the university has also used ArcGIS to enhance public safety. Using a current model of the campus and incorporating up-to-date floor plans, emergency preparedness and evacuation plans were developed. Models and processes were discussed with local authorities and emergency responders to generate a map standard that was distributed to these stakeholders. The safety team created different scenarios and determined several possible routes for building evacuations. These plans were posted on a central website to help fire wardens understand the proper evacuation protocols. Future plans to integrate live security camera feeds into a secure campus

web dashboard would allow the creation of a mobile command and control center.

ArcGIS was even used to design external lighting models for the university's safety walk programs. These models estimated ground illumination based on the type of light fixtures and any interference caused by vegetation or building shadows. Maps were then generated and given to grounds personnel to take corrective measures in illuminating unsafe areas.

## Enhancing the Campus Experience

To help students and visitors easily find their way around campus, the university developed an interactive room-finder application using institutional data. Users can input the building name and



The interactive room finder provides the ability to determine the user's current location and find the best path to a new destination.

room number they wish to find, and the application generates a detailed map showing the floor plan with the desired room highlighted. Visitors can look up their destination using the online tool and determine the nearest parking area before arriving on campus. This enhances visitors' experience and helps them save time.



Zoomed view in the room finder.

The interactive room finder will soon become available on mobile devices. Users will be able to take a picture of a wall marker to determine their current location and then enter their new destination. The map will show several route options—

shortest path, indoor or outdoor routing, elevator access for the handicapped, or stair access for those who want more exercise.

Another future project will use administrative data to help students select classes based on spatial proximity. An application is being developed that will allow students to enter their ID numbers and generate maps that show their classroom locations, as well as the proximity to the next class, based on a specific time and day. This will help students familiarize themselves with the campus and select a schedule that offers reasonable travel times between classes.

"GIS technology offers endless opportunities for our processes to grow," says McCaffrey. "Processes that used to take weeks can now be done in minutes. Being able to see the entire picture at once is an option we've never had before. GIS allows us to plan at a much higher level than we could have ever imagined. Now, we look for new ways to view scenarios and come up with better ideas to manage them."

With all the efficiencies gained in their research, institutional, and administrative processes using Esri technology, the University of Calgary earns an A for GeoDesign and is well on its way to becoming a university of the future.

For more information on how you can put GeoDesign into practice, visit [esri.com/geodesign](http://esri.com/geodesign).

## Related Podcast

### [More Accurate Mapping with 3D Photogrammetry and Lidar Data](#)

Aldo Facchin of GeoSoft explains why the integration of two types of remotely sensed data can help create more accurate maps. [Listen to the podcast](#). [8:00 | 8 MB]

(This article originally appeared in the Winter 2011/2012 issue of *ArcNews*.)

# Operations and Maintenance

# Taking Efficiency to the Next Level at City College of San Francisco

## ArcGIS Server Based Central Repository and Accessibility for Facilities Management

Karen Richardson, Esri

Attended by more than 100,000 students each year, City College of San Francisco (CCSF) maintains and uses 300 facilities spread across 11 campuses in the City of San Francisco, California. People of diverse backgrounds, ages, and occupations have attended the college since its founding in 1935. CCSF is one of the largest community colleges in the country, and the college



City College of San Francisco is spread across 300 facilities on 11 campuses.

confers the most associate degrees in arts and sciences in the state of California.

College facilities are managed by two departments: Facilities Planning and Buildings & Grounds. Traditionally, these departments relied on senior engineers and personnel to maintain facility information, which was shared through paper plots or word of mouth. Some existing paper floor plan plots were digitized a decade ago for general reference, but records of maintenance and upkeep of buildings remained firmly entrenched in paper-based methods.

Although recent construction of several facilities introduced the use of computer-aided drawings, both departments lacked a system to easily manage and disseminate the data. This resulted in challenges when gathering information; time was lost searching for data and determining if it was up-to-date. The ability to decipher how many and where assets existed was difficult. The attrition of personnel was also a concern as valuable institutional knowledge was lost when staff members retired. Newly hired staff required a lot of time to learn about the facilities.

## Seeking a System for Data Sharing

CCSF needed a centralized and flexible system to help organize and deliver facility information. Part of the system needed to assist the college with correctly identifying the current level of physical accessibility in all classrooms and buildings according to the Americans with Disabilities Act (ADA). This required the collaboration of several additional departments across the campus to deliver all the information on a publicly available online Web service.

After reviewing many software packages for functionality and ease of programming, CCSF chose ArcGIS Server. Says Mono Simeone, project manager, CCSF GIS Mapping Collaborative, "The software's scalability, performance and stability, enterprise capability, and built-in AJAX capability make it easy to manage and deploy."

CCSF facility management staff contracted with i-TEN Associates, Inc., an Esri Business Partner located in Berkeley, California, which had previously digitized CCSF's facility data and made it accessible on an internal Web site.

Several departments, including Facilities Planning, Buildings & Grounds, the Campus Police, and Information Technology Services, and the American Disabilities Act and Health and Safety committees worked together to create the system. Now GIS server technology stores, manages, and displays facility and grounds data in a central repository for everyone to use.

## From Paper to Empowerment

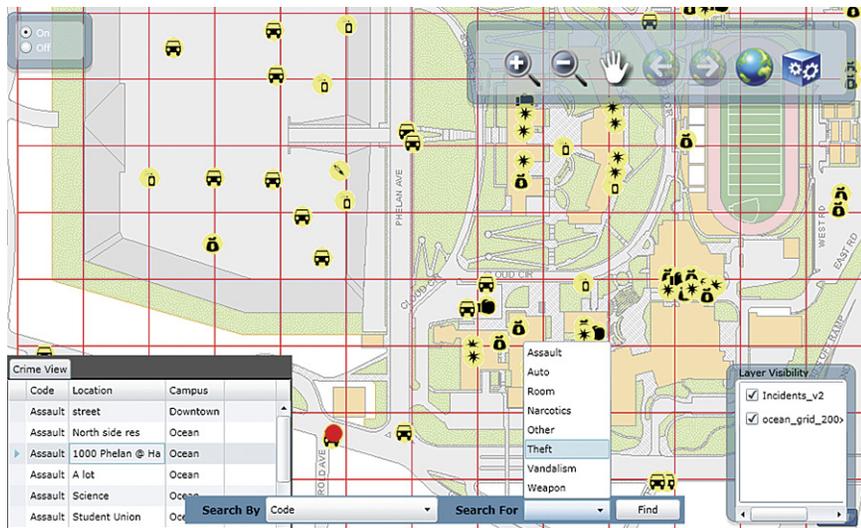
First, the team applied a data model to interior spaces or floor plans. ArcGIS Server, using an Oracle relational database management system (RDBMS), stores, edits, and displays the descriptive and spatial data accessible through a simple interface for both secure and public Web sites. Next, the team created Web applications with ArcGIS API for Microsoft Silverlight, an API for building cross-browser and cross-platform rich Internet applications on top of the GIS. The Web applications serve data for use throughout the college. "The creation of the applications was very straightforward," notes Simeone.

The first application provides access to ADA information at all campuses in the district. It displays features necessary for persons with mobility issues to navigate the campuses. These features include path of travel, parking for the disabled, accessible entrances, and elevators. The application offers several queries to find buildings, rooms, student services, and staff on campus. The result is a map with helpful features for navigation and a report on the room with a picture. The next iteration of the application will implement a routing service using ArcGIS, which provides point-to-point and optimized routing.

This successful application led to more meetings with campus staff from Facilities Planning and Buildings & Grounds. There was a lot of interest in viewing utilities campuswide, including identifying individual features. An application was developed

allowing staff members to use a secure intranet site to display all underground and some surface utilities. "This was the first time we have been able to view all the utility assets at one time," says Simeone.

CCSF also has a campus crime application that allows incidents to be queried by campus, crime type, and date. Incidents within buildings are easily located using a unique space identifier from the GIS. However, incident locations occurring outside buildings are captured using a grid, or mesh, that covers the entire campus. Future plans include the development of a Web-based map service tool to capture x,y coordinate locations of incidents.



CCSF's campus crime application locates incidents using a grid across the grounds and can be queried by campus, crime type, and date.

## GIS Exceeds Expectations

Since the college maintains an Esri campuswide site license, CCSF was able to add new GIS seats and employ existing GIS-knowledgeable staff. Both of these factors made the application implementation easy and economical.

The system now allows data to be centrally stored for more efficient management and sharing. Staff and administrators are able to view and query the facility data at any time from all over the CCSF campus. Departments can tailor a map service to meet their needs, and data can be updated and served to staff or the public in a timely manner.

This implementation of GIS for facility management has exceeded the goals created by the college. CCSF hopes to introduce GIS and facilities management as even bigger parts of how the college operates, manages its assets, and serves the community in the future.

(This article originally appeared in the Spring 2010 issue of *ArcNews*.)

# A Garden's-Eye View

## Botanic Garden Adds New Tools—GIS and Remote Imagery

### Ericka Witcher, Collections Supervisor, Montgomery Botanical Center

Montgomery Botanical Center (MBC) in Coral Gables, Florida, serves as a repository of information in the form of population-based, documented, living plant collections. With 120 acres in a subtropical latitude, the nonprofit research institution is able to specialize in palm and cycad taxa that would have difficulty growing elsewhere in the United States. People of all backgrounds—from students to hobbyists to commercial growers—can observe and examine unusual, rare, or endangered specimens they might not have the opportunity to see in the habitats of origin or in side-by-side comparative collections that would not occur in the wild. Due to the exotic origins or sensitive nature of many plants in the collections, however, the center must work to create and maintain an environment that provides their individual needs for life and growth. To that end, staff members are continually looking for new ways to assess the garden property and analyze both its biologic and geologic resources.

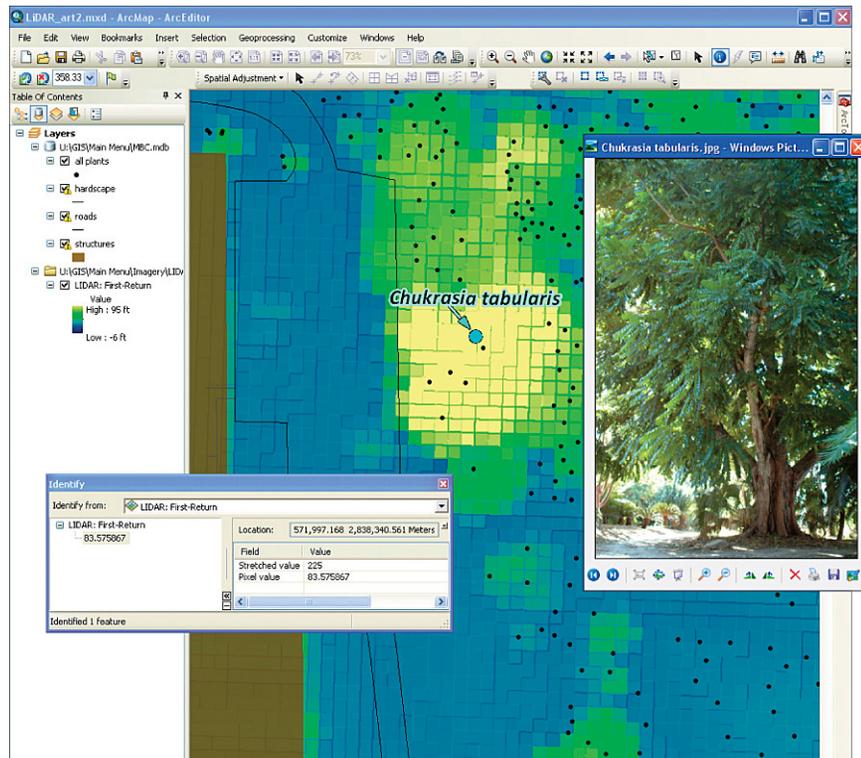
Like other botanic gardens, for several years, MBC staff had used aerial photographs to examine the tree canopy and other features that were difficult to thoroughly evaluate from ground level. Orthophotographs (planimetrically corrected aerial photographs) and uncorrected aerial photos are frequently used in many different industries, including botanic gardens, for many disparate

purposes and are readily available through a variety of sources (e.g., the [US Geological Survey \[USGS\] website](#) or state or county websites). These photos by themselves provided a good general sense of how areas were developing, but the staff experienced a fair amount of difficulty integrating them with its AutoCAD-based maps, so their utility was somewhat limited. Staff wanted a way to view the photos and the maps at the same time, as well as use other types of imagery, then be able to perform spatial analysis.

An [ArcGIS for Desktop](#) Standard software grant from Esri for botanical gardens and zoological parks provided an all-in-one solution. Two MBC staff members had prior ArcGIS experience, and with the help of an additional intern, by late 2009 they had completely converted their old mapping system to a GIS and their CAD files to georeferenced feature classes. MBC was then able to add one more tool to its garden shed: remote-sensing data and imagery.

The ability to use remote-sensing data in conjunction with map files opened up entirely new ways of visualizing the garden property. Tree canopies were accurately identified by species by overlaying the mapped plant points onto the orthophotos. Map files of road edges and lake boundaries from 10 years

before were adjusted to align with their current locations. Instead of looking at information imposed on a representation of the property, the information was examined in view of the property as a whole in the real world.



*Chukrasia tabularis* (Burmese almondwood) is prized for its beautiful hardwood. This specimen at Montgomery Botanical Center (MBC) is the Florida state champion tree and was first identified as a candidate through examination of lidar imagery (scale is in feet).

MBC also lacked an accurate elevation map. The landscape in South Florida is flat enough that a gain of even one-third of a meter is a substantial difference in regard to the water table and underlying soil, which are of great importance to plants, but such a subtle variation is often difficult to detect while performing fieldwork. To remedy this, in 2010, MBC staff made its own contour map with the [ArcGIS Spatial Analyst extension](#), using a bare-earth light detection and ranging (lidar) image of the property. Lidar imaging uses the measurement of time it takes a laser pulse to be transmitted from and reflected back to an overhead receiver (like an airplane or satellite) to generate a visual dataset. In other words, while aerial photos create a two-dimensional horizontal image, lidar adds a third dimension: elevation. Lidar also is increasingly freely available via download from local, state, and federal government agency websites (e.g., the [USGS website](#)). A bare-earth lidar image displays ground-level data as opposed to treetops and rooflines. With this height information added to the maps, staff could see geologic aspects that it could only intuit before. Important low-lying inland areas, as well as property high points, were clearly identifiable, and the labeled contour map provided practical delineations for fieldwork.

A first-return lidar image also offered a lot of utility for other vegetation-assessment projects. First-return images illuminate all the topmost surfaces of the study area—in this case, canopy height and coverage. In one project, an undeveloped section

of the property filled with both an invasive exotic plant, *Schinus terebinthifolius* (Brazilian peppertree), and protected mangrove trees needed a thorough evaluation to determine the most efficient course of action for managing the land. Canopy height and density were examined in the lidar images, and transects were distributed and performed accordingly. The invasive plant was not found to be as pervasive as feared, and as a result, eradication efforts were scaled down proportionally.



Vegetative and geologic characteristics, like canopy and elevation changes seen here along the Palm Walk, are quantifiable with lidar-integrated maps.

For another project, staff adapted a conventional forestry analysis using first-return lidar images to appraise height and breadth information to establish potential candidates for national or state champion tree status. This was done by simply overlaying the

plant point feature class over the first-return image and visually identifying the highest canopies. The plant curators also applied their in-field knowledge of the various species' usual growth habits to propose more individuals for assessment, the height and spread of which were also checked in the lidar map. As of this writing, 27 trees had been awarded state champion status by the Florida Division of Forestry, and 2 trees received national champion status from American Forests.

Overall, says MBC executive director Patrick Griffith, "GIS has made many basic botanic garden tasks here much more efficient and planning much more effective. It has helped our many audiences better visualize what we seek to communicate."

By employing imagery in ArcGIS for Desktop and adapting some of the more basic and conventional uses of lidar for regional landscapes to the localized, relatively small-scale botanical garden, MBC staff saved many hours of laborious fieldwork and gained a nuanced understanding of the property and plants under its care.

*Ericka Witcher is the collections supervisor for Montgomery Botanical Center in Coral Gables, Florida. Her work there involves using GIS for research and maintenance of the plant collections.*

(This article originally appeared in the Spring 2012 issue of *ArcNews*.)

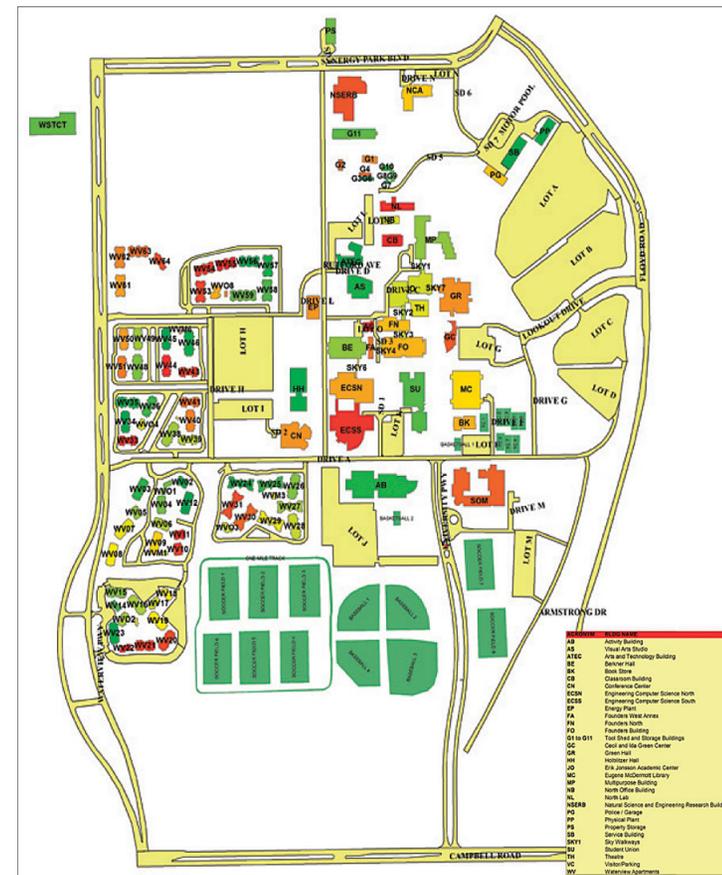
# University Enhances Its Logistical Tracking System with GIS

The Multifaceted Tool Is Used Throughout the University of Texas, Dallas (UTD)

Nicolas A. Valcik, UTD Office of Strategic Planning and Analysis

In 2001, the University of Texas, Dallas (UTD), developed an in-house application to more effectively calculate the square footage of its campus structures. Named the Logistical Tracking System (LTS), this system was originally used as a facility inventory and accounting costs system that generated reports on federal research cost recovery and state facility inventory reports.

Once the system was brought online, its power and flexibility became apparent to other departments. The university police were interested in tying security devices, such as cameras, to LTS to locate personnel through their assigned office spaces. Environmental Health and Safety wanted to track hazardous materials shipments from delivery point to destination and accurately inventory and locate all hazardous materials on campus. Facilities Management wanted to be able to locate water and electrical lines, and Telecommunications wanted to be able to locate telephone and Internet cables on an accurate campus map. There was a general need for a new campus map—preferably color coded—to display on the university Web site and on campus kiosks. Furthermore, there were requests for the application to include a Web interface and to generate printable floor plans. The university's wish list kept growing.



The current map that was produced in 2006 of the main campus at the University of Texas, Dallas (UTD), with ArcGIS.

It was clear that these needs exceeded the existing capabilities programmed into LTS. Therefore, a new component had to be found—one that could enable the university to map out the campus infrastructure, track materials and personnel, and improve the dimensional calculations of the campus structures. The best option available was to create an enterprise geodatabase utilizing ArcSDE technology. The technology's capabilities—which enable robust multiuser editing, storage, and access of very large geospatial databases—and its synergy with LTS's tabular structure made the ArcSDE geodatabase a logical choice. [Note: At ArcGIS 9.2, ArcSDE stopped being sold as a stand-alone product. It is now included with both ArcGIS Desktop and ArcGIS Server.]

The university's strategic planning office, which was heavily involved in the production of LTS, employed a developer who also held GIS certification and could work with existing blueprints and CAD drawings to input room measurements. UTD is also home to the Bruton Center, a research facility that focuses on the integration of geographic information systems, spatial analysis, and exploratory data analysis in the social sciences. Assistance from the faculty and students who worked there would be invaluable for integrating ArcSDE technology into LTS. Finally, UTD's geosciences department routinely uses remote sensing, geospatial information science, and GIS products to conduct research on geologic formations. To test their equipment, the geosciences faculty and students regularly scanned campus

buildings, such as the Cecil and Ida Green Center. They also recorded GPS coordinates for many campus structures, which could be incorporated into LTS.



Three-dimensional scan of the Cecil and Ida Green Center on the UTD campus.

The core of the GIS module was the creation of accurate floor plans that linked data from all other elements in LTS to produce final plans and reports. Three sources of dimensional data were CAD files, traditional blueprints, and manually recorded room measurements. If there was a discrepancy between the CAD files or the blueprints and the manually recorded information, the manual data took precedence. It was imperative that the dimensions be recorded as precisely as possible, particularly for those rooms that were shaped like pentagons or trapezoids or had rounded walls. Once room dimensions were recorded, a

shapefile could be created and imported into LTS. The shapefile would derive additional attributes from the existing data tables. Thus, room numbers, personnel assignments, or any other information that might be desired could be linked to the shapefile to create accurately scaled and labeled floor plans.

Since LTS tables are linked to shapefiles, the system will prevent the user from entering data on a nonexistent building or room and from attaching any type of information, such as hazardous materials or security infrastructure, to a location without data first being input into the system. The system is flexible enough to provide working maps of the campus infrastructure without incorporating the preliminary data into the permanent record. It also provides an audit trail of user modifications and can restrict access to certain modules based on the user's job responsibilities.

## Expansion of LTS

The inclusion of an enterprise geodatabase in LTS enabled a significant expansion of the system. In 2006, information on hazardous materials was input into LTS to track laboratory inspections, record the National Fire Protection Standards 704 or "fire diamond" ratings for each laboratory, track the location of hazardous materials from the receiving point to their destination on campus, and identify the locations of waste containers through bar code identification markers. In addition, a jurisdictional map was constructed for the campus police so that

they would know the boundary of their arrest authority. LTS was also able to generate that campus map that was so needed.

The university relied on graduate students who were trained to become GIS operators. While the experience of working on this project was beneficial to the students' education, this arrangement meant that the staff had to devote more time to train and oversee the students' efforts. However, the benefits derived from adding an enterprise geodatabase to LTS greatly outweighed these challenges. Between fiscal year 2001 and fiscal year 2003, the upgraded LTS reaped a cost savings of \$1.68 million for the university since the LTS application was developed in-house (Cost Savings Report FY 2001–2003 reported to State of Texas from UTD. Sizable cost savings still occurred with the LTS project after FY 2003).

## The Future of LTS

At present, LTS is used on a daily basis by numerous staff members at UTD. With more than 100 users, there are constant minor updates being performed to the application. LTS has recently been upgraded to .NET standard (January 2009), and programming is now going to evolve the reporting capabilities for queries against the system since .NET is more capable than the older .ASP configuration.

*Dr. Nicolas A. Valcik is associate director for the Office of Strategic Planning and Analysis and clinical assistant professor for the Program of Public Affairs at the University of Texas, Dallas. He is the author of Regulating the Use of Biological Hazardous Materials in Universities: Complying with the New Federal Guidelines (2006, Mellen Press). As a result of this effort by Valcik, with Esequiel E. Barrera, UTD won the National Safety Council/Campus, Safety, Health and Environmental Management Association Award of Recognition (Unique or Innovative Category) in 2006.*

(This article originally appeared in the Spring 2009 issue of ArcNews.)

# Smartphone App Aids District's Facilities Maintenance

Jim Baumann, Esri

Students and faculty in the Los Angeles Unified School District (LAUSD) can report graffiti, broken benches, or other repair issues using a smartphone application that is integrated with the district's GIS.

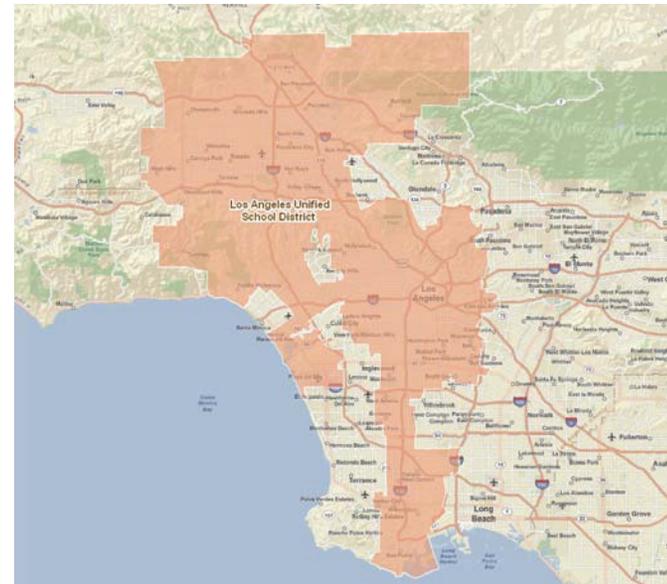
LAUSD is responsible for educating more than 675,000 K–12 students annually and is the second-largest public school district in the United States. The district manages facilities that include 1,065 K–12 schools; more than 200 education centers, adult schools, and occupational skill and learning centers; and dozens of warehouses and storage yards within the district's 710 square miles.

The district has used Esri's GIS software since 1990 for administrative tasks including student enrollment forecasting and analysis, school boundary maintenance, student safety, disaster planning, and facilities operations and management. As additional applications were added, the GIS gradually evolved into an enterprise system.

"GIS has played a big role on the administrative side of our operations," said Danny Lu, business analyst for LAUSD. "As we continued to expand our use of the technology, we realized that

there were some commercial applications that could be easily integrated with ArcGIS and would fit into our existing workflow."

Upkeep of the numerous LAUSD facilities requires an army of administrative, maintenance, and technical staff members who are continually evaluating and processing the many service requests submitted each day. The district implemented a data



LAUSD, the second-largest public school district in the United States, covers 710 square miles.

collection system that allows campus staff to easily report nonemergency issues. This relieves the operations department from some inspection and reporting responsibilities and lets it concentrate on the repair and maintenance of the school district's assets.

In 2010, the district contracted with Esri partner CitySourced to implement LAUSD Service Calls, a smartphone application permitting LAUSD students and faculty to report issues related to the repair and maintenance of school facilities, such as graffiti, broken benches, or damaged sprinkler systems.

"We wanted to take advantage of today's technology and provide our community with an intuitive tool that allows them to easily document maintenance issues and send those reports directly to us so that we can resolve



A smartphone app integrated with the Los Angeles Unified School District GIS lets students and faculty members report graffiti or other repair issues.

them," said Lu. "As an added benefit, by using the application, students and faculty members of LAUSD are provided with a sense of ownership while building community pride."

CitySourced uses Esri's ArcGIS application programming interface (API) for smartphones in the LAUSD Service Calls application so that the school district can integrate the volunteered data from the incident reports with its authoritative ArcGIS database. This helps the school district keep the GIS database up-to-date for its IBM Maximo asset management system.

Kurt Daradics, director of business development at CitySourced, said, "The LAUSD Service Calls implementation at LAUSD is an end-to-end solution. Incidents are recorded on the mobile devices and sent to the CitySourced servers hosted by Microsoft Azure. Our servers route the issues directly into LAUSD's IBM Maximo asset management system as service requests, where they are reviewed and subsequently resolved by the district's maintenance department."

Daradics indicated that the LAUSD Service Calls application will eventually be able to automatically query the operational asset layers in the ArcGIS database so that the asset ID can be determined. The ID will then be attached to the asset specified in the incident report submitted by the LAUSD community member. This will allow all information related to the asset (maintenance history, age, and replacement costs) in the GIS database to be

automatically retrieved so the school district can use its GIS to better manage and maintain its assets.

The LAUSD Service Calls application can be downloaded for free to the user's smartphone.

When reporting an incident, the user is prompted through a series of drop-down lists to specify the incident location, type, required maintenance, and description. This report and accompanying photograph is sent to LAUSD's asset management system, where it is reviewed by a moderator to determine the required course of action. If maintenance is required, a work order will be generated, prioritized, and routed to the appropriate department for action.

According to Lu, the system also provides feedback to the person or persons reporting the complaint.



A user reporting an incident is prompted through a series of steps to specify the incident details and supply a photo.

When a work order is generated as a result of a service call, the asset management system automatically sends a response to the sender, indicating the incident report has been received and assigned. Students and faculty can use the CitySourced application to search for the calls they have placed. Under My Reports, they can view the status of an incident. This feedback loop demonstrates to the community that LAUSD is aware of and is working to resolve their concerns.

(This article originally appeared in the Spring 2012 issue of *ArcUser*.)

# Campus iPhone App Helps University of Oregon Students Negotiate Their Way around Campus

Application Was Created Using ArcGIS API for iOS

Matthew DeMeritt, Esri

University and college students today use iPhone apps to organize their class schedules and homework assignments, practice their French, and locate the best restaurants and clubs off campus. At the University of Oregon (UOregon), they also use a new iPhone app to find their classes, the library, and campus events.

The [UOregon iPhone application](#), offered by the university and created by the InfoGraphics Lab of the school's Geography Department, helps students find their way around the sprawling campus. The app, designed using Esri's [ArcGIS API for iOS](#) and data pulled from the lab's existing geodatabases, is meant to acclimate students to their new school during the university's Week of Welcome orientation.

Few university graduates forget the experience of being lost on their first day on campus. Negotiating one's way around a new school can be intimidating, mainly because large learning institutions occupy a lot of acreage. The standard physical map usually included with the course catalog often isn't necessarily the best tool for orienting oneself to a new environment. Dynamic maps on digital devices contain much more information than a sheet of paper can display.



The new UOregon iPhone app offers an alternative to a paper map as a means to navigate the large campus.

## Inspiration for the iPhone App

Over the last 20 years, the InfoGraphics Lab gradually built its database with geographic information about the school to help fulfill the university's operational needs (such as showing maintenance crews where the circuit breakers are located) and populate its digital maps with features. In 2007, the lab decided to create an interactive web map of the campus to help new students and faculty members familiarize themselves with their new environment. The progenitor to the iPhone

app, the [University of Oregon interactive campus map](#) currently serves as one of the public front ends of the University of Oregon campus GIS.

The InfoGraphics Lab began to kick around the idea of an iPhone app in 2009 during a joint research project with the university's Planning, Public Policy, and Management Department. The project involved developing an iPhone app called Fix This, a mobile survey tool for assessing the condition of sidewalks and bike lanes.

That project's success enabled the lab's team to respond to the request of Richard Lariviere, the university's then-new president, to develop an app specifically for the university. "The president and his communications team wanted to pursue an iPhone app that located events, such as baseball games and rallies, as well as other campus-related information," said Ken Kato, assistant director of the InfoGraphics Lab.

"Because the lab built and maintained the campus GIS databases and had experience with the ArcGIS API for iOS, we knew we could deliver an app to serve the campus, especially incoming freshmen, for whom the campus is an entirely new environment."

## Moving beyond Basic Mapping

The team members' experience using Esri's web mapping APIs and beta iOS software developer kit (SDK) helped them build the initial iPhone prototype app in just a couple weeks. This was a

unique feat, given the functionality of the application. The team wanted to go beyond adding geocoding points on Apple's Map Kit or Google Maps and instead create something that could accommodate fast-rendering, high-resolution maps and the room-level GIS data the lab maintains. To do this without outside vendor help, the lab's staff members pulled from all the resources in the ArcGIS for iOS SDK and Esri desktop software as well as their own data.

"We asked ourselves, 'Why don't we use our own custom maps rather than Microsoft's or Google's?'" said Dana Maher, lead programmer and a graduate student. "We have high-quality cartography that's maintained to be current and accurate on a daily basis, and we wanted to put it to use."

A data collection that spanned decades, including aerial photos of the campus from 1913 and 1948, had been digitized and was ready to be served from the geodatabase. Team members knew that Esri's [ArcGIS Server](#) would allow them to add their own custom cartography as basemaps in their viewers. "We liked the idea that we could serve those maps out as a tiled image cache," said Maher. "This meant only the necessary image tiles [the ones being viewed] dropped instantly into place as users zoomed and panned."

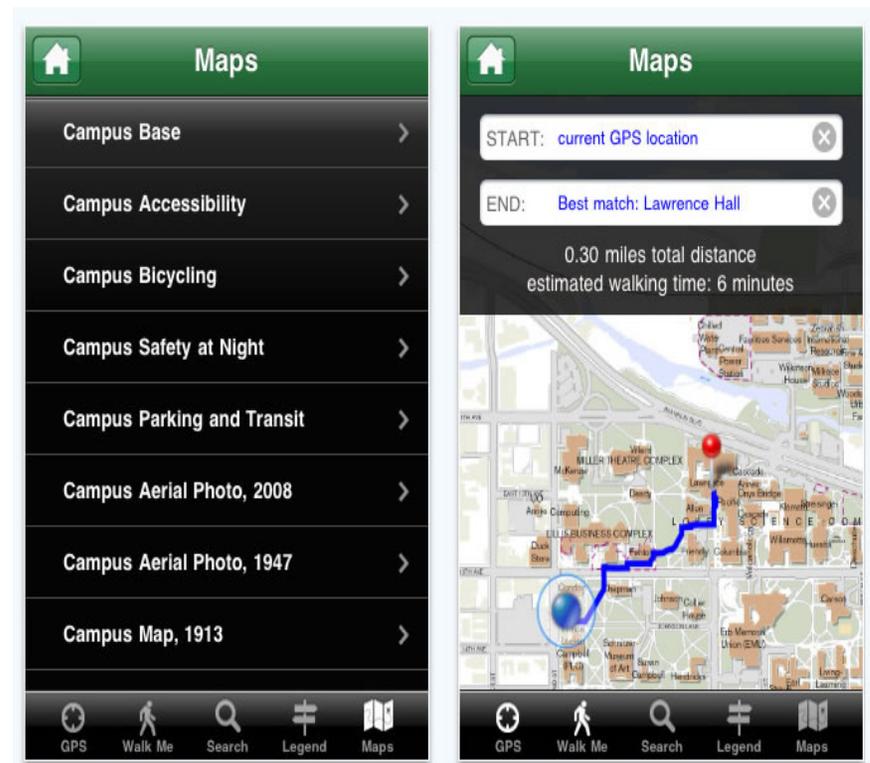
Working at the lab are staff and students from the Geography Department who are passionate about geospatial technology and eager to show off what they can do. As such, showcasing the

whizbang element of today's geographic server technology was a major objective during the project. "We wanted to demonstrate the depth of the mapping available with Apple and Esri technology," Kato said. "The sentiment at our meetings was that our research applications have really matured and it'd be great if we could mirror some of that functionality on the iPhone app."

The Find Maps function in the latest ArcGIS API for iOS struck Kato as particularly well-suited for allowing users to choose the basemap they wanted. "I thought that was perfect for us to incorporate a similar function because we have many cartographic visualizations of the campus that we already maintain for our web application," he said. "The 1917 basemap shows [that] the room we're in was in the end zone of our old football stadium. In 1948, the campus had undergone some major changes but still looked very different [from now]. We included two old basemaps, a map from 1913 and an aerial photograph from 1948, because we wanted students to experience the various temporal views of the university grounds." In addition to those vintage basemaps, the app includes the following maps: Bicycling (which shows all the campus bicycle lanes), Safety at Night (which plots the safest routes for nighttime walking), and Accessibility (which shows the location of wheelchair ramp entrances).

## Week of Welcome

The free app plays a major role in the university's Week of Welcome, the official orientation period for incoming freshman students. Finding dorms, bookstores, registration events, and classrooms can be tricky during this time, so the lab team made a point to include a directions feature in the interface. The app uses

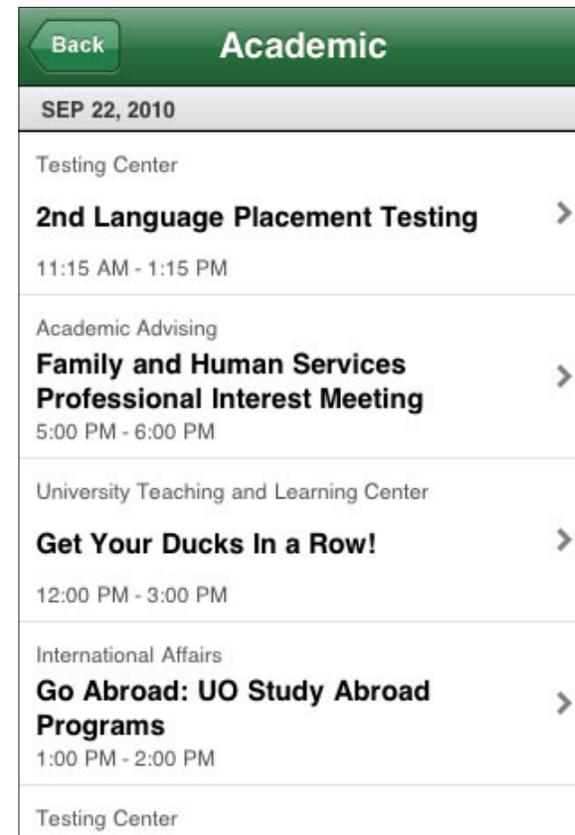


UOregon iPhone app users can select from a list of multiple map views of the campus (left). Tapping the "Walk Me" icon on the bottom of the screen provides From and To fields for sidewalk routing.

the onboard iPhone GPS to show where the user is on campus to provide sidewalk-level routing. This Walk Me feature takes users to any campus events that are being fed to the app and also can be used to display a route with start and end points anywhere on campus, including an estimated walking time. "We wanted to give it a routing feature," said Jacob Bartruff, GIS analyst and programmer. "We knew that new students, unfamiliar with the campus, would find sidewalk routing invaluable."

"This was one of the more interesting parts about putting the project together," said Maher. "It was fun to figure out how to extend the iOS SDK to do point-to-point routing. I don't really know of any other university that creates custom campus- and sidewalk-level mobile routing networks."

University of Oregon's mobile mapping technology also helps students locate their classes; access campus security in the event of an emergency; find where campus activities, such as art shows and ballgames, are happening; and keep up with social media. App users can also stay up to date on University of Oregon news and events and view the 295-acre campus with a continuously updated feed of photos and videos. The lab also injected some school spirit into the app by including the institution's fight song, "Mighty Oregon," played by the university's marching band.



An "Events" feature lists upcoming campus events, listed by category. Tapping each event takes users to a detailed description of the event.

With more than 8,000 students and faculty members currently using the UOregon iPhone app, as well as positive feedback and very favorable ratings in the Apple App Store, it likely won't be long before other colleges and universities integrate mobile GIS mapping capabilities to create an immediate, on-the-go

experience that is always available for students right at their fingertips.

Visit the [InfoGraphics Lab website](#) to learn more about the UOregon iPhone app.

(This article originally appeared in the February 2011 issue of *ArcWatch*.)

# A New Dimension

## 3D GIS aids resource planning and facility management at Tufts

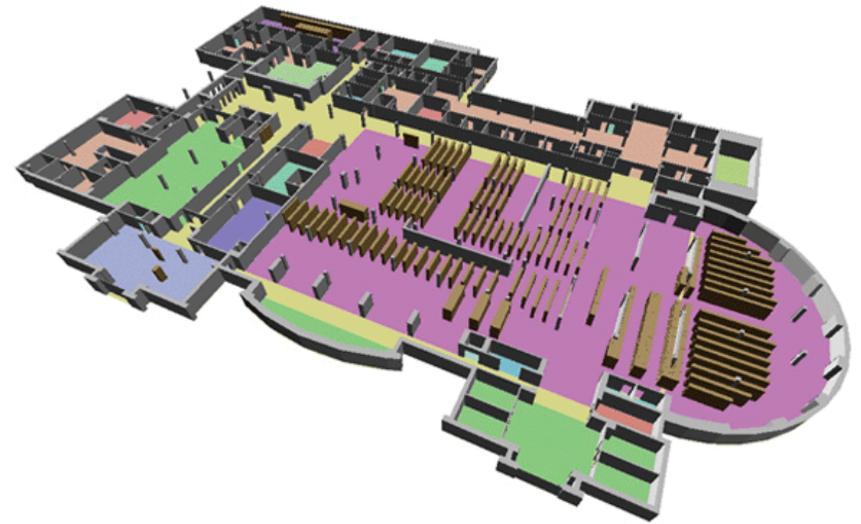
Jim Baumann, Esri

The Tufts College Library has grown from a small collection of books the university's first president shared with students to a library system with holdings of more than 1.2 million volumes and other materials. To manage this collection, the library developed a 3D GIS-based library information system that incorporates the library's existing data management programs.

Founded by the Universalist religious denomination in 1852, Tufts University is a small liberal arts school located in Medford, Massachusetts. The university has an enrollment of about 9,000 students and fosters a tradition of social responsibility.

The Tufts College Library began as a collection of books kept by Hosea Ballou II, the first president of Tufts. Ballou circulated the books from his office in the College Building, now Ballou Hall, personally signing them out to students. As the college grew, adding schools and campuses, the library system expanded to meet the increasing needs of the institution.

Today, the largest facility in the Tufts University Library system is the Library for Arts and Sciences, now called the Tisch Library, on the Medford campus. Tisch houses the majority of the library system collection including 700,000 books, 30,000 electronic journals, 20,000 electronic books, and 20,000 video recordings.



Main floor of Tisch Library showing room use within L-SIMS

The library facilities include a student café, offices, group study rooms, research areas, and a media lab for viewing DVDs and videotapes. In addition, the Tisch Library has an active research instruction program and offers both one-on-one consultations and an instant messaging reference service.

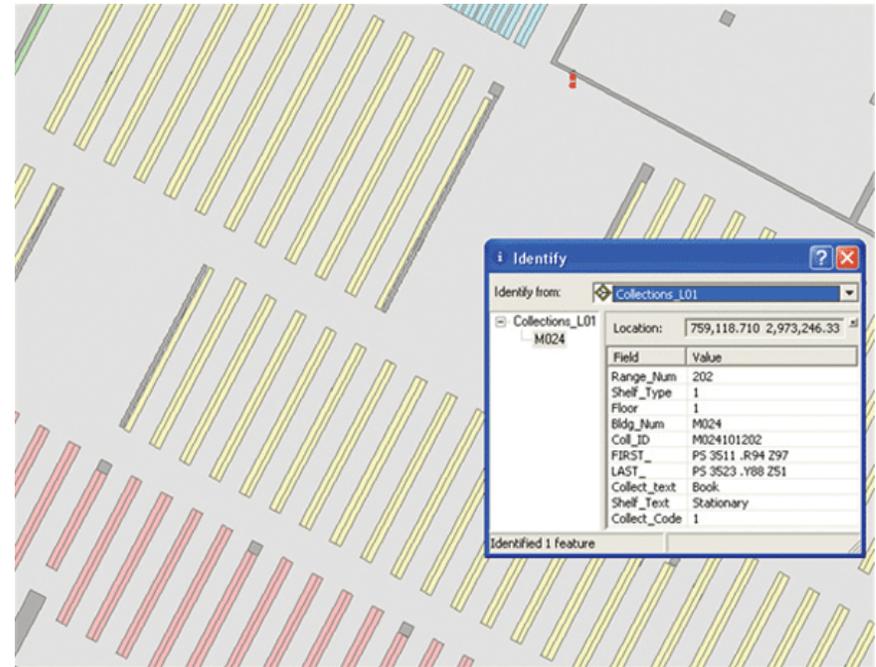
Tisch Library continues growing and evolving, with additions to special collections and the need to provide supplemental materials when new courses are introduced at the university.

Management of its facilities and resources is a significant concern for university library administrators, who are continually trying to improve access to the expanding collections within the confines of the existing space.

Recognizing the need to better manage both its facilities and collections, Tufts Library administrators enlisted a team of university employees, including Thom Cox, technical project manager, and Patrick Florance, GIS center manager, to help develop and implement a GIS-based library information system that incorporated the library's existing data management programs. The project was funded by the Berger Family Technology Transfer Endowment.

Said Florance, "The Tufts University Information Technology group partnered with Tisch Library Information Technology Services [LITS] to create L-SIMS [Library Spatial Information Management System], a fully functioning, 3D GIS-based view of the interior space of the library that merges databases from LITS, facilities management, and various library collections."

The L-SIMS project began with an extensive needs assessment study that involved consultations with library staff and students concerning current and potential use of the library, an examination of existing databases, and a detailed inspection of the library and its contents.



Tisch Library collections database within L-SIMS

After the needs assessment, the Tufts team created a data model for L-SIMS, which involved the development of a unique identifier schema to link the various feature types to the appropriate databases. A significant component of the project was the database development and conversion. The library's CAD floor plans were brought into ArcGIS, georeferenced, and cleaned significantly to create feature topology. The floor plans were ground truthed, and a significant amount of editing was performed in areas that had experienced recent renovations.

"We hired Tufts students to complete the work, so it also became a real-world learning experience for those students looking to further develop their GIS and spatial thinking skills," commented Florance.

About 30 distinct features were coded for the L-SIMS geodatabase, including rooms, walls, doors, doorways, emergency exits, stacks and shelving, fire extinguishers, panic buttons, electrical outlets, computers, and Ethernet connections, as well as the collection itself—all the features that are commonly found within a library. Then several different databases related to those features were integrated into the system. This included the facilities database that identifies room numbers, room use, square footage, who is responsible for the room, occupants, and so on. The LITS database was also included. This holds information about all the computers in the library, such as the computer ID, the processor, whether it has a CD or DVD drive, and all the software on it. Also integrated is the collections database, which stores the different reference numbers and collection types for all the stacks in the library.

L-SIMS helps reference librarians better direct students to the resources in the library in addition to assisting with tasks such as developing plans for facilitating disaster planning, determining the location and contents of special collections, and accessing the availability of computer resources.

The Tufts GIS center used ArcGIS to generate high-quality maps. Key library staff were trained and became ArcGIS users and the data stewards for the new system. Tufts also created a Web-based prototype of L-SIMS using ArcGIS Server.

"L-SIMS really serves as a resource management tool. Several library staff members have commented on how excited they are about the new system," said Florance. Previously, when changes occurred, they would have to remap sections of the library for each specific use—often a time-consuming process. Added Cox, "The ability to quickly generate high-quality maps is one of the greatest benefits of using L-SIMS. Detailed floor maps are posted on each floor of the library that indicate the location of various book collections, as well as important emergency information such as exits, panic buttons, and fire extinguishers. When library resources are altered, the maps must be re-created to reflect those changes."

Now when a student comes to the reference desk requesting help locating a book, the reference librarian can provide an accurate, highly detailed map showing the stack where the book can be found. L-SIMS is regularly updated so the maps produced from the database always reflect the current status of the library collection.

Using L-SIMS, librarians can also analyze the use of specific elements of the Tisch Library collection. Access to those parts of the collection that are in great demand can be optimized

by relocating them to a more prominent location, while those materials that attract less interest can be stored in or relocated to a less prominent place.

"It is the hope of the L-SIMS project team that this foundation work will be the impetus for the future development of a public, Web-based, interactive mapping application to provide comprehensive information and access to library resources. Both students and Tisch staff will be able to explore the contents of the library online and identify topics of interest. For example, a user searching for a specific book could pan to a library stack to see the collection type and the related reference numbers to locate the required material. Or, they could click on a displayed computer to see what software is loaded on it," concluded Cox.

L-SIMS is so successful that several schools and departments at Tufts are asking the library to build geoenabled SIMS or business inventory management systems (BIMS) for them.

(This article originally appeared in the Winter 2011 issue of *ArcUser*.)

# Security, Compliance, and Sustainment

# High Tech Leads to Higher School Safety

City of Frisco, Texas, Wins Esri President's Award

Jesse Theodore, Esri

A hazardous chemical spill in a classroom science lab; a cafeteria kitchen fire; or worst of all, a school shooting—these are the events that school authorities, parents, and public safety officials alike dread. Maintaining school safety and effectively responding to any type of emergency are continuous processes. Thankfully, technology is helping in these endeavors. Better communication equipment, live cameras, and databases with building footprints and other information help schools plan for incidents, and responders get the information they need when an emergency strikes.

One local government's school safety journey just took a quantum leap. The City of Frisco, Texas, now deploys an application called Situational Awareness For Emergency Response (SAFER), which provides fire, police, and emergency responders with access to maps and live data feeds while en route to school incidents. SAFER takes advantage of Esri partner GeoComm's GeoLynx solution, which is built using ArcGIS technology. The system became fully operational at the City of Frisco in 2009.

Using GIS as an integration platform, the City of Frisco is able to integrate volumes of data using an intuitive map interface.

Responders view school maps and other information while racing to an emergency. They have a better understanding of what they're facing when they arrive. Officials at command centers and other remote locations can see a macro-level view of events and drill down to a specific area or room in a school to understand how the response is unfolding. More information is made available in a faster time frame. It's the key to a better response and, ultimately, safer schools.

"The project makes the schools, students, and first responders safer," says Susan Olson, GIS manager, City of Frisco. "It enables public safety departments to better serve the school district. Implementing this system has allowed the departments to



A mobile application in each fire and police vehicle provides up-to-the-minute information about incidents, vehicle locations, floor plans, and site contact information.

reduce operations costs by having all relevant information easily accessible in one place. It lowers risk and better prepares responders on the way to an emergency."

SAFER makes it easier to visualize the scene of the incident and begin planning response immediately. It also improves the communication between the City of Frisco's emergency responders by presenting a common operating picture. Critical decisions can be made quickly by everyone using shared information.

"SAFER has provided us with the kind of information we have always wanted to have while responding to an emergency," says Mack Borchardt, City of Frisco fire chief. "Site plans, floor plans, contact information, and hazard information all feed directly to those first responding units to give them the awareness they need. When you put the cameras on top of that, you're looking at a level of situational awareness that is unheard of in this industry."

The application and its deployment have proved so innovative and successful that the City of Frisco was honored with the prestigious Esri President's Award. The award was presented at the 2010 Esri International User Conference, held in San Diego, California.

"The City of Frisco's SAFER program demonstrates the role that GIS can play in enhancing communications for multiple agencies and ultimately improving emergency response to their citizens," says Jody Sayre, vice president of Client Services at GeoComm.

"The City of Frisco's SAFER project team was highly engaged in this project from day one, and it is very deserving of this award."

## **Bringing Schools and Public Safety Closer Together**

The impetus behind the SAFER application stems from the desire of Frisco Independent School District (FISD) administration to work more closely with the City of Frisco Fire and Police departments to ensure that everything possible was being done to provide for the safety of students. The administration wanted to fully prepare in the event of a catastrophic school event, such as a major fire or school shooting.

FISD also wanted to supply its information to public safety agencies to help them when responding to an emergency. Both of these goals stemmed from the recognition that, at the time, response to a school emergency was mainly paper based. This made it difficult to quickly access information when needed.

Only select emergency vehicles in each fire station had sufficient room to maintain rolling files of information. In addition, there were few common systems or processes in place to communicate changes to the information between the agencies involved.

The City of Frisco's Information Technology (IT) Department works closely with the city's Police and Fire departments. Olson, with more than 18 years of GIS experience—most of it in local government—was in communication with both departments for several years about building a system.

Says Olson, "Our fire chief was certain we could develop a system internally that would take advantage of the good working relationships already in place and the technology the city already used."

After looking at the possibility of outsourcing another company to build a system, a proposal was developed that led to an agreement between Fisd and the City of Frisco. Together, they would develop, implement, and maintain a new application in-house: the SAFER project. Once built, the SAFER system was within budget, saving taxpayers a large amount of money versus outsourcing for a similar system. But as Olson puts it, there was a larger benefit: "SAFER is far superior to what had been previously proposed," she explains.

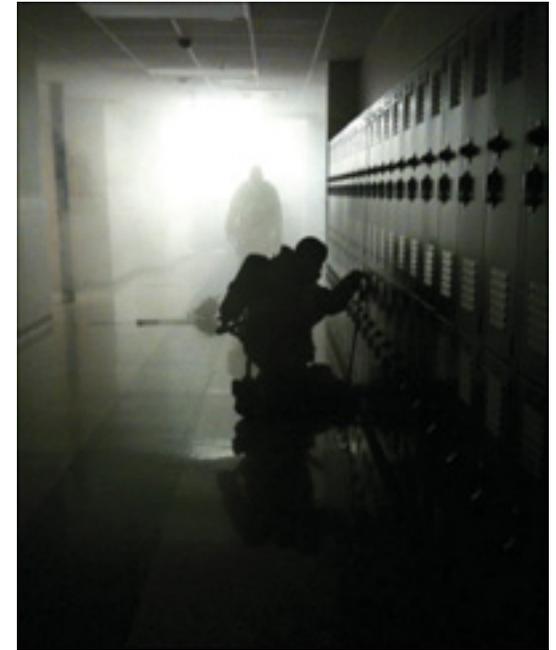
## SAFER

The SAFER applications were built to allow emergency responders to easily drill down into the information they require at a moment's notice. Using touch screen mobile data computers (MDCs) with air cards for network access in all emergency vehicles, first responders can view and interact with the city's GIS databases and mapping functionality. This includes access to all spatial layers of information. In addition, first responders can access online emergency preplan documents for a specific school; up-to-date contact information for school administration; and detailed, georeferenced floor plans for all schools.

Floor plans include visual data, such as room numbers/ names and locations of nurses' offices, administration, special needs students, and hazardous chemicals, as well as roof access. In addition, more than 1,500 video cameras at all facilities are represented on floor plans; each floor plan is hyperlinked to bring up a live video feed with a single click.

All this information is available to first responders via their MDCs, to 911 dispatchers, to emergency management personnel in the city's Emergency Operations Center, to the mobile command vehicle, and to Fisd and city administration personnel via secure Web access.

ArcGIS is used to populate the map framework for all public safety mobile data computers, dispatch workstations, and display in the Emergency Operations Center. When police officers or



The SAFER program includes GIS links to more than 1,500 Frisco school video cameras showing live pictures so that authorities can make better decisions.

firefighters are on the way to a school emergency, they can pull up the GIS map to view the surrounding area, pictometry, detailed floor plans, automated vehicle locations (AVL), and live video streaming from the school cameras.

GIS layers were developed for SAFER specifically to hold school floor plan information, preplan hazard notes and symbols, links to video camera live streams, pictures, and an internally developed Web site with preplanning information and site contacts.

GIS hyperlinks attach the system to a Web page called the Site Detail Interface. This interface compiles information harvested from the Fire Department records system (Firehouse) and an external Fisd Microsoft SharePoint site. This SharePoint site allows Fisd staff to maintain school contact information. The advantage of the SharePoint solution is that the school district has control over the information it sends into the system and is responsible for maintaining it.

The next phase for the City of Frisco is to expand its GIS use to include commercial buildings.

"GIS is not simply a map but a database and analysis tool that serves as a framework for a complex and integral process used by public safety to better serve our community," says Olson. "Our requirements were developed without a specific system in mind, but with GeoComm and Esri, along with an exceptional support staff, we were able to develop something great that exceeded the expectations of all involved."

(This article originally appeared in the Fall 2010 issue of *ArcNews*.)

# No Debate about GIS on Campus

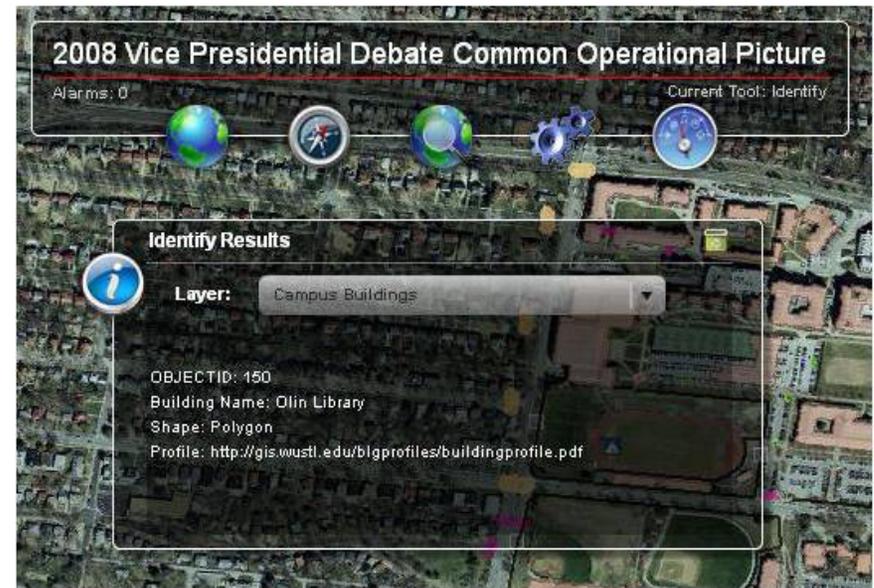
Interactive Maps Helped Organizers Keep Cool When the Palin-Biden Vice Presidential Debate Heated Up

Karen Richardson, Esri

When Washington University, in St. Louis, Missouri, offered its Field House as a venue for the 2008 United States vice presidential debate, university officials had no idea the event would be one of the most watched in television history. Approximately 70 million American viewers tuned in on October 2, 2008, to see Governor Sarah Palin of Alaska, the first female vice presidential nominee for the Republican Party, square off against Senator Joe Biden from Delaware, a 36-year veteran of the U.S. Senate.

However, the [private university](#), founded in 1853, is no stranger to the spotlight, having hosted more national election debates than any other institution in history. The school was chosen to host the 1992, 1996, 2000, and 2004 presidential debates. While it's an honor, planning these affairs is laborious and detail oriented.

Ensuring that the debate went off without a hitch was the responsibility of University Facilities. The department needed to coordinate many events before and during the day of the big event. University and vice presidential debate staff needed a solution that would allow them to view and manage all activities to ensure the proper security details and safe crowd control. To do this, they turned to geographic information system (GIS)



The 2008 Vice Presidential Debate Common Operational Picture (COP) was created in two weeks with the assistance of Washington University, St. Louis County Emergency Management Services, and Esri. Officials could use the application to pan a map of the campus, zoom in to a specific area, and call up information about buildings.

software from Esri, which would provide the ability to visualize the entire campus and all the activities happening for the debate in real time. GIS allowed them to

- Visualize where all police were on campus.

- Plan and monitor public viewing areas, speakers, and live media broadcasts.
- Manage campus closures, class relocations, and traffic flow.

"Hosting the vice presidential debate meant we had to get a complete picture of all the campus facilities and how the events would play out," said Aaron Addison, university GIS coordinator, Washington University. "In the past, paper maps were used to plan and coordinate on the day of the event. We knew we could do better than static maps and had a vision to provide faster, better access to information in a more accurate manner."

The university holds a site license for Esri GIS software, teaching several courses with the technology as well as using it for campus mapping projects. Since a repository of facilities information was already stored in ArcGIS format, Addison's thought was to find a way to tap into this data to plan for and execute the debate.

## Innovative Thinking Leads to Interactive Application

Addison had attended the [Esri International User Conference \(Esri UC\)](#) in the summer of 2008 and saw a demonstration of the [ArcGIS API for Flex](#). "I was impressed with the software's ability to display map information quickly over the Web," said Addison.

ArcGIS API for Flex is a development framework integrated with Adobe Flex Builder 3. Using the Flex API, available free from the ArcGIS [Resource Center](#), developers can combine Web services

from Esri's [ArcGIS Server](#) with other Web content and display it in simple, dynamic mapping applications over the Internet. Using [ArcGIS services](#), users can transform their local data into a visually rich interactive map, query and display GIS data features and attributes, locate addresses, identify features, and perform complex spatial analytics.

At the time of the Esri UC, the ArcGIS API for Flex hadn't been released. Working with Esri's St. Louis regional office, the university customized a beta copy of the software to create an application to deliver a real-time view of the campus and activities during the debate.

The application, which the university called the 2008 Vice Presidential Debate Common Operational Picture, had to be useful for the university afterward to help justify the expense. Receiving funding for creating the application was based on implementing the technology for projects following the October event. "We had an immediate need in our own campus police department and, of course, our Facilities department also showed interest," said Addison.

## Collaboration Was Key

Finding useful data was important. Imagery for the entire region was downloaded from [ArcGIS Online](#) and fused with high-resolution aerials of the campus that the university gets each year. The St. Louis County Emergency Management office,



Imagery for the entire region was downloaded from ArcGIS Online and fused together with high-resolution aerials of the campus that the university flies each year.

along with Addison and his team, loaded necessary detailed vector information including streets, places of interest, university facilities, and street data. The university also coordinated with the city and county of St. Louis, both Esri GIS users.

This collaboration was important since the university spans both county and city lines. While the east entrance is located in the city, the west entrance is located in the county. Ensuring data was accurate and worked together made logistics planning possible.

"We had to coordinate with both the St. Louis city and county security for road closures and barricades as well as people staging [and] bike mounted police and officer stationing," said Brad Averbeck, Facilities manager, Washington University. "The fact that both were standardized on the same platform made

what could have been a headache of a task into something very manageable."

Within two weeks of receiving funding for the project, the 2008 Vice Presidential Debate Common Operational Picture was complete and ready to go. Using the application meant the university could provide the necessary maps on the day of the event, but not in the traditional way. "We were worried about past debates where we would print 60 or 70 maps on the event day but, between delays and changes, they weren't very useful for security," explained Addison.

### Keeping an Eye on the Debate

Instead, police officers and VIPs kept tabs on where barricades were being placed, security details were being set up, and traffic was being detoured by viewing mapped information in real time through the ArcGIS Flex application. During the debate, two rooms on campus were open for viewing the digital maps: a communication area filled with police officers coordinating activities and a joint operations center (JOC), where everyone from police commanders to event coordinators and security managers could watch what was happening in real time on campus.



Security dispatchers and university officials and other VIPs kept tabs on where barricades were being placed, traffic was being detoured, and security details were being posted.  
(Photo by Aaron Addison/Washington University.)

The groups used the same interface, which was kept simple and easy to understand since there was no time for training. Viewers could zoom and pan to see locations as well as click on icons to find more detailed information. For example, clicking on a building would provide information about that building such as the number of rooms and emergency exit information.

Officer location information was fed into a geoRSS feed that received coordinates from GPS-enabled phones donated for

the day by Sprint. Clicking on an icon of a police officer on the map brought up a list of information including the officer's name, scheduled shift, and assignment. Officers also used geoRSS to update viewers if security details changed, such as road barricades being moved.

The 2008 Vice Presidential Debate Common Operational Picture kept everyone updated on the debate staging. The data that was required was readily available, and there was no wait time to get questions answered or understand emergent situations. A St. Louis police officer commented, "This is the closest thing to 'CSI' I've seen that actually works."

### Recycle, Reuse, Redeploy

Today, the Flex application has been modified and redeployed. Two important areas where the application is used include the university's police dispatch and University Facilities. Campus police dispatchers use an application that's a modified version of the 2008 Vice Presidential Debate Common Operational Picture for emergency situations. Aerials and building footprints are available in the system through a secured connection. Officials can access information about buildings that might be necessary in an event like a fire or hostile situation. By clicking on a building, information comes up instantly, including the names of primary contacts and structural component information such as the location of doors and whether there are lobbies in the buildings. Fire exits and handicap access can also be found, along with what

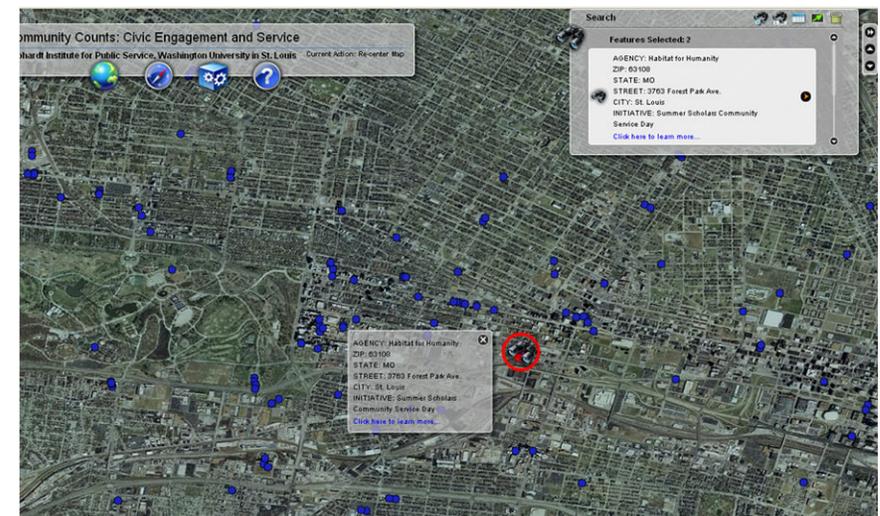
kind of power sources are available and where equipment like water and electricity shutoffs are located.

University Facilities uses the application to accurately see campus information in one place, covering all buildings ranging from new construction to historic buildings dating back to the early 1900s. Viewing utilities helps with maintaining new building plans and keeping an accurate record of the land use. Having information accessible via the Flex-based ArcGIS application—instead of through handwritten notes on the margins of paper drawings or locked in the heads of engineers—has led to many successful endeavors. When a contractor removed several light poles but didn't remove the wiring, the university was able to look at historic maps digitally, easily relocate the wiring, and replace the lights.

## Sky's the Limit

Using the current GIS system, the university plans to launch several projects based on the success of how GIS was used for the debate. Using ArcGIS API for Flex enables campus administrators to provide emergency notifications to students for real-time events such as inclement weather, building closures, and safety notifications. Routing student records, maintaining compliance with the Americans with Disabilities Act, and creating campus walking tours are other projects the university looks forward to implementing.

Will the university continue its long and storied hosting of public events, which began in 1904 with the first Olympics played in the Western Hemisphere? "I don't see why not," said Addison. "The university has been selected to host [debates] for five consecutive elections. I can't wait to see what GIS innovations are available to us for the next one."



Washington University plans to launch several projects using the application created using ArcGIS API for Flex. One application will show where students and faculty perform community service on campus.

(This article originally appeared in the December 2009 issue of ArcWatch.)

# Going Green at Pomona College

The "College in a Garden" Performs Comprehensive Audit of Energy Systems Using Spatial Data

Jon Roberts, CTG Energetics, and Bowen Close, Pomona College

Pomona College is the founding member of the Claremont Colleges, a unique consortium of seven affiliated institutions that also includes the Claremont Graduate University, Scripps College, Claremont McKenna College, Harvey Mudd College, Pitzer College, and the Keck Graduate Institute of Applied Life Sciences. Pomona College, located in Claremont, California, had a vision to be "a college in a garden" from its inception in 1887. Today, ivy and palm trees coexist under the warm, sunny skies of Southern California.

The college is committed to sustainability. Recently, it built three buildings to Leadership in Energy and Environmental Design (LEED) building standards (see "[The New Gateway to Green Building](#)"). One of those, the Richard C. Seaver Biology Building, was awarded a Silver LEED certificate, placing it in the top 1 percent of all academic laboratory buildings in the country in terms of energy-conscious design.

In 2007, Pomona College president David Oxtoby signed the President's American College and University Climate Commitment, an agreement that commits Pomona College to a variety of deadlines and programs for moving toward carbon neutrality. One of the first milestones was to conduct a campus-

wide greenhouse gas inventory. Pomona College expanded the inventory to include a holistic range of sustainability and tied it to the academic mission of the college. The college worked with Esri Partner CTG Energetics, Inc., based in Irvine, California, to develop an innovative approach to the inventory. CTG trained and coordinated a team of six students who spent most of the



Members of the Pomona College audit team.

summer conducting the inventory. At the end of the audit, the college hired its first director of sustainability to ensure that the college continues to move toward a greener future.

## **A Central Repository for Data Collection**

The college maintains a site license of Esri software and used ArcGIS as the central data repository and analysis platform for significant portions of the audit, including landscape water use, embodied greenhouse gas emissions, green waste generation, storm water management, and on-site renewable energy potential. An aerial topographic survey, producing an accompanying aerial image of Pomona College, was performed in 2006 and saved in CAD file format. The CAD file was processed in AutoCAD to hide all the layers except the key landscaping elements that were required. The file and accompanying image file were then imported into ArcGIS and Microsoft Access and digitized by a student with prior class experience using the software. The result was a detailed geodatabase of Pomona's landscaping, including layers for building footprints, roof sections, streets, sidewalks, hardscape, landscape zones, and tree canopy.

Once the area was digitized, including 60 buildings and one million square feet, the audit team, consisting of six students, used the digital map data to create customized landscape audit forms that characterized Pomona College's landscape and identified irrigation and storm water conservation opportunities. Map books consisting of ten 11" x 17" pages reflecting the

different zones of the college were used to assist with collecting the information accurately. Data from the field surveys was entered into the geodatabase.

Data on the number of roof segments, including slope, orientation, roofing material, and shading; parking lots; and other information, was also captured on the audit forms. This was later used to calculate solar energy generation potential on rooftops and parking lots; irrigation water use; water conservation measures, including "California-friendly" landscaping; and storm water management measures, such as permeable paving, green roofs, and other low-impact development (LID) strategies.

## **Translating Book Knowledge to the Real World**

CTG provided background training sessions to introduce the student auditing team to the basic issues, technology, and auditing processes for each sustainability issue. The training sessions were held both indoors and outdoors and took two to four hours. This helped ensure data quality and consistency.

CTG and the audit team also visited various campus sustainability examples and LEED-rated green buildings—the Richard C. Seaver Biology (Silver certified) and the Lincoln and Edmunds Buildings (Gold certified), Pitzer's new LEED-rated dorm, and Harvey Mudd's LEED-rated Hoch Shanahan Dining Hall. The team examined the low-water-use landscape features of these buildings, as well as storm water measures and other

relevant green building features. Permeable paving, low-water-consumption plant palettes, efficient irrigation systems, landscape shading, and building energy impacts were all examined. This direct experience of sustainability measures aided the student auditors in identifying appropriate areas for additional applications as they conducted their field surveys.

Once the training was complete, the students fanned out across the campus to conduct the auditing fieldwork and entered the results into audit forms. The GIS database was then updated to reflect changes on the ground identified by the audit team. The geodatabase and supporting data were used to analyze current resource use, including current landscape irrigation requirements and estimated storm water runoff, then analyze a range of sustainability measures and on-site renewable energy potential.

"Using GIS allowed us to perform the survey in a more efficient way," says Jon Roberts, PhD, principal consultant, director of building sciences, CTG. "There was a tremendous amount of data that we were able to process and use to make informed decisions that we couldn't have done any other way."

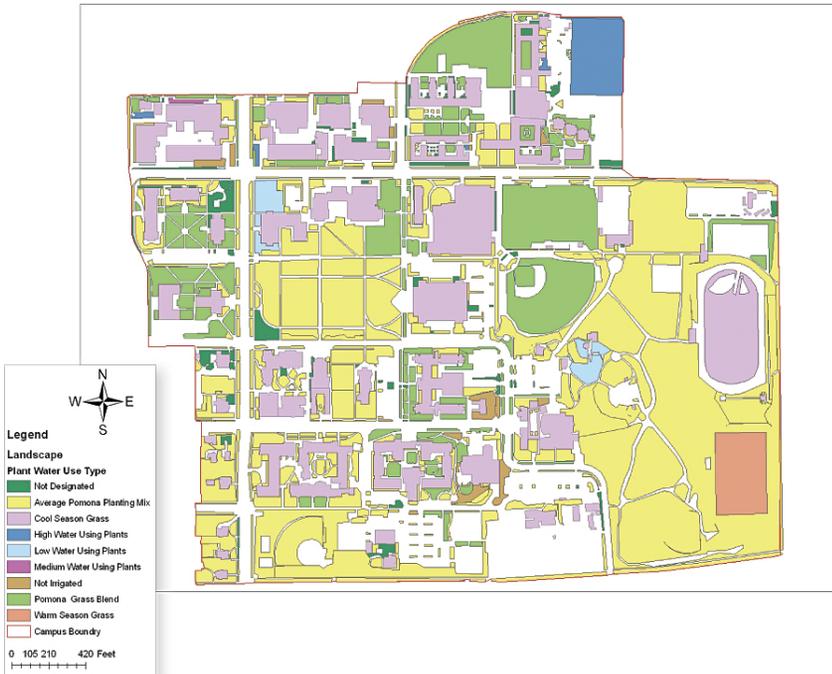
## Findings on Campus

According to the survey results, the campus should continue to move toward a California-friendly landscaping palette, which includes water-efficient, drought-tolerant plantings; increased use

of permeable hardscape, such as mulch; and reduction of the use of turf grass.

The Grounds Department used the information found by using ArcGIS to identify areas for changing landscape plant choices and irrigation technology. Since the completion of the audit, the department has

- Reduced water days on all landscaped areas by one day
- Reduced the water schedule on planter beds to two days/week
- Reduced watering of turf areas to four days/week (excluding newly planted areas)
- Changed 5,148 square feet of shrub area from spray irrigation to drip
- Changed 1,705 square feet of turf to mulch
- Changed 21,179 square feet of shrub area to mulch
- Changed 1,428 square feet of turf to shrubs with drip irrigation
- Changed 1,641 square feet of ground cover to mulch



Auditing the water usage on campus has allowed the Grounds Department to change its landscape palette and reduce water usage.

"Using GIS to view and analyze this vast amount of data had a significant impact all the way around," says Bowen Close, LEED Accredited Professionals, director, Sustainability Integration Office, Pomona College. "Incorporating spatial data into our audit was very helpful; we could calculate areas that we wouldn't have had time to solve by hand otherwise."

Providing a mechanism for everyone to view the campus data and analyze energy use introduced a systems-based approach

to the analysis. "I'm starting to see others view GIS as a critical tool for collecting sustainability data," says Roberts. "Seeing the various meters, such as energy and water meters, and knowing which buildings feed which data is so much more organized and efficient than having to take file cabinets full of data and organizing it."

(This article originally appeared in the Winter 2010/2011 issue of ArcNews.)

# Learn More

Overview on GIS

[esri.com/gis](https://esri.com/gis)

This site provides an introduction to GIS for those new to it.

*The Role of GIS Technology in Sustaining the Built Environment*

Patrick Wallis, AICP, LEED AP, GISP

[esriurl.com/builtenvironment](https://esriurl.com/builtenvironment)

Read this free e-book from Esri and learn how GIS can be used as an enabling technology for better communication and data interoperability to manage the built environment.

*GIS for Facility Management*

Stu Rich and Kevin Davis, PenBay Solutions

[esri.com/ifma](https://esri.com/ifma)

Download a free copy of this white paper to read about the value of GIS and its many applications for facilities management.

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## Contact Esri

380 New York Street  
Redlands, California 92373-8100 USA

1 800 447 9778  
T 909 793 2853  
F 909 793 5953  
info@esri.com  
[esri.com](http://esri.com)

Offices worldwide  
[esri.com/locations](http://esri.com/locations)